

# **Joint SCOR/IAPSO Symposium on Deep Ocean Exchanges with the Shelf**

Edward R. Urban, Jr.  
Scientific Committee on Oceanic Research  
Robinson Hall  
College of Marine and Earth Studies  
University of Delaware  
Newark, DE 19716  
phone: (302) 831-7011 fax: (302) 831-7012 email: [Ed.Urban@scor-int.org](mailto:Ed.Urban@scor-int.org)

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## **LONG-TERM GOALS**

The goal of this symposium is to bring together a critical mass of scientific expertise to synthesize the state of the science on the topic of deep ocean exchanges with continental shelf areas.

## **OBJECTIVES**

The objectives of the symposium are to (1) synthesize the state of the science and make recommendations for future research related to (a) processes due to shelf waves, internal tides, shelf-break upwelling and sinking, eddies and filaments, storms and extreme events that produce effects over time scales of weeks to one or two years; (b) transport over the shelf and shelf break of riverine and estuarine input of sediment and fresh water; (c) dissipation of tidal motion along the continental margins on time scales of hours to days; (d) the physical controls of chemical and biological fluxes between the shelf and the open ocean that can affect the ecology of such regions; (e) cascading and deep water formation; and (f) coupled physical-chemical-biological models, generally at local to regional scales, that have a more realistic description of the exchanges at the shelf edge; (2) determine where further observational programs (using improved technology) are needed to improve understanding of shelf-break processes and to provide help with the formulation of more realistic models of the fluxes between the shelf and the deep ocean; and (3) foster collaboration between developed and developing countries that have interest in the shelf zone.

## **APPROACH**

The symposium has been planned by a working group of the Scientific Committee on Oceanic Research (SCOR) and the International Association for the Physical Sciences of the Oceans (IAPSO) led by John Johnson (University of East Anglia, UK) and Piers Chapman (Texas A&M University). The symposium will be held in Cape Town, South Africa on 6-8 October 2008, followed by a planning session for research cruises among African participants on 9 October. Papers from the symposium will appear in a special issue of the European Geosciences Union open access journal *Ocean Sciences* in 2009.

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Piers Chapman and John Johnson will convene a symposium on Deep Ocean Exchange with the Shelf at the IAPSO meeting in Montréal in July 2009. The next meeting of joint working group will be held in the same week, at which time they will follow up on the results from the symposium.

## **WORK COMPLETED**

A bibliography of references on deep ocean exchanges with the shelf has been created and posted at <http://www.mth.uea.ac.uk/~h080/WG129.classified.bibliography2.doc>.

Most of the working group's effort so far has been devoted to planning of the symposium (see program at <https://www.confmanager.com/main.cfm?cid=1293&nid=9433>).

## **RESULTS**

The bibliography cited above is the only tangible result to date, as the group's symposium will occur just after the end of the reporting period.

## **IMPACT/APPLICATIONS**

The shelf break is a region of steep slopes, strong narrow currents, internal tides, shelf waves and significant vertical motion. With the advent of much finer resolution in ocean models, it is a good time to address the links between the shelf circulation and the deep ocean circulation at the shelf break. Improved understanding of the exchanges between the shelf and the deep ocean will be useful for more realistic models for studying climate, the carbon cycle, sedimentation and marine ecosystems. The increased detail in the improved models often leads to prediction of features that have not yet been observed. This can lead observational oceanographers to include fieldwork in their cruise plans that will either establish the existence of these new features or test the validity of the models.

Even as ocean models become more realistic by having much finer resolution in space and time, there are still significant problems in resolving the high variability that occurs around the shelf break between the deep ocean and continental shelves. Modellers have often regarded the shelf break as the nominal seaward boundary of shelf models or the coastal boundary of deep ocean models. Even with the finest resolutions in ocean general circulation models, the shelf region is poorly resolved, with only a few grid points. Ocean observers have had difficulty in securing measurements at the edge of the shelf due to the narrowness of the currents and steep slopes. However, new technologies are now enabling measurements in such challenging environments. For example, swath bathymetry gives accurate bottom topography, the ship's dynamic positioning allows precise placing of moorings, and acoustic Doppler current profilers allow measurements throughout the water column, even in strong currents. At the same time, fine-scale (1km or less) coastal models such as the Regional Ocean Model System (ROMS), with multiple depth layers, are now being used to model the movement of water, chemical species, and sediments on the shelf, and are being connected to biogeochemical models of the local ecosystem. Meshing these models into larger-scale deep ocean models offers the chance to resolve some of the unknowns.

The exchanges and fluxes that occur near the shelf break are important parts of the global ocean circulation. These fluxes include sediments and biomass as well as seawater. Coupled ocean-atmosphere general circulation models require, for example, the input of freshwater outflow from rivers. These inputs are generally added at the location of the river. But, in reality the fresher water

flows along the shelf, sometimes for considerable distances, before it crosses the shelf break and enters the deep ocean. Similarly the formation of Antarctic Bottom Water and other dense water masses often occur over continental shelves before they flow offshore. An example of a biological flux is the movement of patches of krill on and off the Antarctic shelf, as described by Murphy et al. (2004).

Strong tidal mixing at the shelf break and over variable topography is an important feature in the energy balance of the Earth's oceans (see, for example, Jayne and St. Laurent (2001), Wunsch and Ferrari (2004)). Internal and surface tides are built into shelf models but are usually absent from deep ocean general circulation models. Strong mixing associated with significant topography is an important component in the theories of the global thermohaline circulation. Coastal models often use terrain-following coordinate systems (sometimes called sigma coordinates). Although this method deals better with the changes in shelf slopes compared with models using standard grid boxes, they introduce significant problems due to pressure gradient force error as described in Berntsen and Furnes (2005). The symposium will discuss the progress of these new models, and encourage the use of such models for looking at the details of processes near the shelf edge and for the inclusion of biogeochemical fields. The symposium will also encourage further observations in regions that can validate and enhance understanding of the model output. Improved models and observations leading to a better understanding of the processes that occur between the shelf and the deep ocean will be of benefit in maintaining fish stocks and dealing with threats of pollution from oil and gas wells, and for studying river runoff and sedimentation. Coastal areas are often regions of enhanced primary production due to coastal upwelling. Understanding the carbon cycle in such ecosystems is relevant to climate studies.

## **RELATED PROJECTS**

A new generation of high-resolution models is under development, including, for example (i) the Nucleus for European Modelling of the Ocean (NEMO) begun in France, but now forming the basis of a wider European project and using interactive nesting (see [www.lodyc.jussieu.fr/NEMO/](http://www.lodyc.jussieu.fr/NEMO/)); (ii) the next generation of the Hamburg Shelf Ocean Model (HAMSOM), called the Vector Ocean-Model (VOM), including biological and physical coupling on an unstructured adaptive grid; (iii) the Imperial College Ocean Model (ICOM) using an unstructured mesh; and (iv) the Hybrid Coordinate Ocean Model (HYCOM) a data-assimilative hybrid isopycnal-sigma-pressure coordinate ocean model. Users of these models will participate in the symposium.

The ongoing international Antarctic Zone (iAnZone) project is concerned with modelling and observations in the Southern Ocean, including strategies to understand climate variability in the Antarctic Zone. It includes the Synoptic Antarctic Shelf-Slope Interactions Study (SASSI); a programme of observations over the Antarctic shelf and slope as part of the International Polar Year (see <http://roughy.tamu.edu/sassi/sassi.html>). One of the co-chairs of iAnZone will participate in the symposium.

The carbon cycle in the shelf and upwelling zones is an important ingredient for the modelling by the Climate Variability and Predictability (CLIVAR) programme. The discussion of applications on chemical and biological fluxes needs to be in collaboration with projects such as the International Geosphere-Biosphere Programme (IGBP) Land-Ocean Interactions in the Coastal Zone (LOICZ) project and the SCOR/IGBP Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project. IMBER is particularly concerned with how long-term global change (including changes to the deep ocean/shelf fluxes) will affect biochemical cycles and ecosystems. Other important collaborators are (i) the Surface Ocean-Lower Atmosphere Study (SOLAS) for their interest in biogeochemical

interactions and feedbacks between ocean and atmosphere, and (ii) GEOTRACES, the international study of global marine biogeochemical cycles of trace elements and their isotopes.

Individuals involved in several of these projects will be attending the symposium and/or be involved in other activities of this group.

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